

# NU-WRF Release 3 Project Plans

Document Revision 11  
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## Overview

**Release Date:** Functionally Complete Beta Estimated Early Fall

**Summary:** NU-WRF Release 3 consists of a software package that builds on Release 2 earlier this year. It includes updates to a number of added components like LIS and SDSU, additional couplings, such as aerosol-microphysics, and tools to help with model runs and analysis. Additionally, use cases that exercise these new enhancements will be made available for the release along with documentation on building the software and running the use cases.

## Software Components and Features Supported

### 1. Vendor software and updates:

- a. WRF 3.2.1
- b. WRF/Chem 3.2.1
- c. WPS 3.2.1
- d. WPP 3.2
- e. ARWpost 2.2
- f. MET 3.0 (with local patches)
- g. RIP 4.6

### 2. Currently planned team enhancements:

- a. Goddard SDSU 2
- b. LIS
  - i. LIS 6.1
  - ii. ~~LIS surface snow retrievals~~
  - iii. LIS automated spinup configuration
  - iv. LIS Verification Toolkit
- c. Goddard radiation fix
- d. Goddard microphysics update
- e. GOCART aerosol-Goddard microphysics coupling
- f. Tools
  - i. Fire emission preprocessor
  - ii. ~~Standard, automated validation tool~~
  - iii. Sanity check option (~~generalized~~)
  - iv. Build system improvements (build-all for NAS, incremental build)
  - v. GOCART2WRF enhancements (nested domains, GEOS5 GOCART data, store 3D pressure data)
  - vi. Chemical emissions preprocessor (to use 3D pressure data)

### 3. Previous team enhancements:

- a. Goddard microphysics, online coupling
- b. Goddard radiation, online coupling
- c. GOCART aerosol-Goddard radiation coupling
- d. LIS, online coupling
- e. Severe convection diagnostics in WRF and WPS
- f. SDSU
- g. Build-all packages for NCCS
- h. *Data utilities:* merra2wrf/geos2wrf, gocart2wrf, sst2wrf

## Development Plans

The following table describes all the enhancement being added to NU-WRF (besides bug fixes), a brief statement on how we intend to implement it and a brief statement on how will intend to verify that the enhancement is producing expected results.

<b>Task 2.a - Goddard SDSU 2</b>	
<i>Contributors:</i>	Toshi
<i>Description:</i>	Originally planned a minor upgrade, but upgrading to version 2 instead. Contains minor bug fixes to SDSU. Additional updates include: GOCART input options added to WRF input, GCE-SBM 3D option, SBM moment output, grads control file automatically written, and Morrison two-moment support.
<i>Implementation:</i>	Import from external SDSU codebase (website download).
<i>Tests:</i>	Execute the standard SDSU test case. Also could use Roger's AMMA case for more NU-WRF specific test. Add to regression tests.
<i>Completion:</i>	Final version added. Not tested under NU-WRF build yet.
<b>Task 2.b.i - LIS 6.1</b>	
<i>Contributors:</i>	Jim, et. al.
<i>Description:</i>	Updates LIS to version 6.1. Includes support for Noah 3.1, 3.2, SPoRT Daily GVF data, North American Regional Reanalysis (3d) (NARR) data, NCEP's modified IGBP MODIS landcover data, specify direction for output variables. Added Noah 3.2 bug fix.
<i>Implementation:</i>	Import from external LIS codebase.
<i>Tests:</i>	Run LIS-WRF test case.
<i>Completion:</i>	Done. Undergoing validation by Anil.
<b>Task 2.b.ii - LIS surface snow retrievals</b>	
<i>Dropped from Release 3 due to lack of need.</i>	
<b>Task 2.b.iii - LIS automated spinup configuration</b>	
<i>Contributors:</i>	Sujay, Eric
<i>Description:</i>	Aid user in automatically configuring LIS for spinup run.
<i>Implementation:</i>	Will consist of scripts to read in NU-WRF files specifying a configured domain, and use this information to automatically configure LIS to use the same domain.
<i>Tests:</i>	Use case 12 could be used for verification. Requires additional datasets for evaluating the tool output.
<i>Completion:</i>	Done and tested. Is not under a regression test yet.
<b>Task 2.b.iv - LIS Verification Toolkit</b>	
<i>Contributors:</i>	Joe, Anil, Jon
<i>Description:</i>	Tool to enable standardized evaluation and inter-comparison of land model outputs.
<i>Implementation:</i>	Import from external codebase in LIS repository.
<i>Tests:</i>	Will include sample data along with case 12.
<i>Completion:</i>	Done. Requires evaluation.
<b>Task 2.c - Goddard Radiation fix</b>	
<i>Contributors:</i>	Roger, Toshi
<i>Description:</i>	An issue with using different decompositions led to different results in running the same experiment. A fix (which may be limited to certain grid types) is necessary to correct this problem.
<i>Implementation:</i>	Already incorporated into aerosol coupling/radiation.
<i>Tests:</i>	Bugs fixed/no longer reproduced.
<i>Completion:</i>	Done. Includes updated radiation. Several additional bugs were identified

and fixed.

### **Task 2.d - Goddard Microphysics update**

*Contributors:* Roger, Toshi, Tao

*Description:* New version of the cloud microphysics, which is expected to be necessary for some of the aerosol coupling work. This is a prerequisite for coupling to aerosol.

*Implementation:* Use Tao's new ice microphysics scheme which requires some guidance from Tao.

*Tests:* Will validate against other (non-aerosol) cases with older microphysics as a quick sanity check.

*Completion:* Done. There is a known stratiform/convective issue, however, it only affects the diagnostics.

### **Task 2.e - GOCART aerosol-Goddard microphysics coupling**

*Contributors:* Roger, Toshi, Qian, Shujia

*Description:* Using an improved version of the Goddard microphysics, add support for coupling aerosol interactions from GOCART with clouds based on the various aerosol concentrations. Not planning feedback to GOCART.

*Implementation:* Add additional routines to convert aerosol mass into (a) number concentration of cloud concentration nuclei (CCN) for soluble species and (b) number concentration of ice nuclei for insoluble species. There are additional science considerations to evaluate, such as whether this should be a 1-way or 2-way coupling. Potentially feedback could be parameterized via microphysics precipitation rate. Must change chem array variable to account for this as long as GOCART does not do double counting.

*Tests:* Test new routines without aerosol sources and sinks (offline). Then test interactive aerosol-cloud-land interactions by adding new source-sink terms for GOCART aerosol mass linked to cloud source/sink terms. Cases used include NAMMA and TWP.

*Completion:* **End of September. Implementation is under test.**

### **Task 2.f.i - Fire emission preprocessor**

*Contributors:* Qian, Eric, Roger

*Description:* This program is a third-party preprocessor for preparing some chemistry and emission data for conv\_emiss. The program was originally developed by scientists in Brazil and includes source code from other sources (particularly RAMS). An updated version was released on 14 June 2011 and has been downloaded. A patch to improve the map projection code (specifically, add Mercator and use the WRF code for Lambert Conformal) has been provided to Qian Tan.

The prep\_chem\_sources does not support the GFEDv3 fire emission dataset that is needed by Roger Shi. The GFEDv3 data consists of monthly "total" files, plus daily "fraction" files that must be used together to determine daily emission values. NOAA is working on adding support for GFEDv3 in prep\_chem\_sources, but it is not clear when this code will be available for us to use – if it will take more than a few days, we will need to write our own code.

*Implementation:* Our immediate tasks are:

- i. Add prep\_chem\_sources to the NU-WRF repository.
- ii. Add the map projection patches provided to Qian. We will only modify the map transformation code; the spatial coordinate arrays (which follow the RAMS naming conventions) will be left as is.
- iii. Add support for GFEDv3 to prep\_chem\_sources. If NOAA can provide the source code, we will add this to our repository; otherwise, we will need to write our own subroutines to do this. Sample GFEDv3 data are available from Qian.

*Tests:* Fire emissions case.

<i>Completion:</i> Done. Under evaluation.	
<b>Task 2.f.ii - Standard, automated validation tool</b> <i>Dropped from Release 3 due to evolving requirements.</i>	
<b>Task 2.f.iii - Sanity check option</b> <i>Contributors:</i> Eric, Rob, Shujia, Toshi <i>Description:</i> Build option allows debug checking on the ranges of variables. <i>Implementation:</i> Generalize Toshi's code. Consult with science team on reasonable ranges. Added via Radiation update. <i>Tests:</i> Unit test or use bad inputs to trigger the check. <i>Completion:</i> Done, but not generalized as planned.	
<b>Task 2.f.iv - Build system improvements</b> <i>Contributors:</i> Eric <i>Description:</i> Support for building on PLEIADES at NAS. Support for skipping unnecessary cleans when rebuilding executables. <i>Implementation:</i> Add PLEIADES-specific build configuration. Only clean directories at user request (or if inconsistent build settings are detected for WRFV3). Support additional build targets: - <i>allclean</i> : clean all NU-WRF components before any builds - <i>cleanfirst</i> : force cleaning for all user-specified targets. Records previously used build settings after each WRFV3 build to indicate use of MPI, Chem support, and LIS-specific real.exe. This may trigger a full clean if the two do not match. <i>Tests:</i> NAS: Run an example case and compare results. Incremental Build: Build twice in row. Modify a source file. Build again to make sure it builds only the needed source file. <i>Completion:</i> Done. Not fully tested on Pleiades.	
<b>Task 2.f.v - GOCART2WRF enhancements</b> <i>Contributors:</i> Eric, Shujia, Roger <i>Description:</i> The GOCART2WRF program currently processes "offline" GOCART aerosol data generated with GEOS-4 meteorological data. These files are in netCDF3 format, are organized into separate files for each aerosol species, and only exist for cases prior to 2007. The NU-WRF scientists immediately need support for new "on-line" GOCART data generated with GEOS-5 – these data are output in netCDF4 format, are organized with all species put into one file per time level, and include an extra sea-salt size bin that is not usable as-is with the WRF GOCART module. Longer term, support may also be needed for "offline" GOCART data from GEOS-5—these are also netCDF4 (but with files using a .nc suffix), and the species are again written to separate files.  Qian needs to determine how to convert the sea salt size bins to match that used with the WRF GOCART module. She will provide this information to SIVO staff. SIVO also needs to know from Qian's group which format(s) should be supported in the future. Finally, we may need to inquire if special netCDF4 subroutines are required to process the on-line data (netCDF4 should be used regardless, as this library can be used to read netCDF3 files).  The existing GOCART2WRF program is not very modular and needs significant revision and reorganization. Rather than modify the current program to add support for the new formats, it's probably better to rewrite the code, cannibalizing those subroutines that are small and limit themselves to particular tasks (e.g., horizontal interpolation). <i>Implementation:</i> Add support for nested grids (Done. Must rerun for each nested domain.) The immediate task is to process the "on-line" GEOS-5 GOCART data for	

	<p>Roger Shi. Several options exist:</p> <ol style="list-style-type: none"> <li>Convert the "on-line" GOCART data into "off-line" GOCART format so it can be used by the current GOCART2WRF. Any code written to do this would be temporary "throw-away" software.</li> <li>Begin writing a new GOCART2WRF that will accept the "on-line" GOCART data but is more modular and is designed to add new formats. For the immediate task, only support the on-line GEOS-5 format data.</li> <li>Modify the current GOCART2WRF to accept the new "on-line" GOCART data. This does not seem warranted.</li> </ol> <p>Also added several bug fixes.</p>
<i>Tests:</i>	Testing with AMMA use case.
<i>Completion:</i>	Done. Under test.
<b>Task 2.f.vi - Chemical emissions preprocessor</b>	
<i>Contributors:</i>	Eric, Hamid, Jules, Qian, Roger
<i>Description:</i>	<p>The conv_emiss program is a preprocessor included in NU-WRF (WRFV3/chem) for certain chemical emissions. One flaw is the handling of vertical interpolation of "GOCART background data" (monthly averaged chemistry data originally from GMI and made available to WRF-Chem users). This background data is released on terrain following, pressure-based sigma coordinates, but the data does not include the surface pressure needed to convert from sigma back to air pressure. In conv_emiss, an assumption is made that the surface pressure is 1023 mb everywhere, which is a poor assumption in mountainous regions.</p> <p>The "GOCART background data" is actually an input to the GOCART aerosol program (or module when run within GEOS). In GOCART, the instantaneous surface pressure from GEOS is substituted, and the "background" levels are assumed to coincide with the GOCART aerosol levels (same horizontal and vertical resolution). The GOCART2WRF program somewhat follows this logic: first, the instantaneous surface pressure in the GOCART output is interpolated to WRF grid columns; second, these interpolated values are used to calculate the air pressure at each GOCART (and GOCART background) grid point.</p>
<i>Implementation:</i>	Modify prep_chem_sources to calculate and output 3d pressure from the new "GOCART background" data. Modify the vertical interpolation code to use these pressure values (see convert_emiss.F, near line 475)
<i>Tests:</i>	Wildfire case.
<i>Completion:</i>	End of September. Mostly complete, except for interpolation update required in convert_emiss.

## Use Cases Supported

The NU-WRF Release 3 package contains use case examples, which are numbered following the convention in the shared project folder on Discover (see <https://modelingguru.nasa.gov/docs/DOC-1895> for details). The use cases include namelist files, source files for initial conditions (GRIB files, processed GEOS and MERRA datasets, processed GOCART aerosol data, processed SST data, etc), and customized WPS TBL files (as appropriate). For official inclusion in the release, a use case requires: (1) all necessary code components completed or working reasonably; (2) contributed input configurations and datasets in the shared project area; (3) successful execution by other team members; and (4) an established regression test to exercise aspects about the case/code. A common source of boundary conditions (e.g., GFS data) could optionally be established and used as appropriate.

Supported (recent additions highlighted in **bold**):

- **01 - Aerosol Monsoon Cycle over India (May/June, 2005/2006)** (May need to be split into two cases)

- **02 - 2009 CA wild fires (Coupled GOCART aerosol-radiation)**
- 05 - California snow (00Z 12/30/05 - 00Z 01/01/06)
- 06 - Hurricane Wilma 2005
- 08 - C3VP (00Z 1/20 - 00Z 1/23 2007)
- 09 - MSFC: Real-time NSSL: 10 April 2009 (tornado/large hail outbreak, SE U.S.)
- **10 - MSFC: Real-time NSSL: T.S. Erin in Aug 2007**
- 11 - MSFC: Real-time NSSL: 28 March 2007 (tornado outbreak)
- 12 - Very dry/mostly clear sky with deep PBL growth (14 July 2006)
- **13 - Aerosol pollution propagation over US (January 01, 2006)**
- 15 - Typhoon Morakot 2009
- 16 - MSFC: Real-time NSSL: 9 April 2009 (tornado/large hail outbreak, SE U.S.)

Incomplete/not supported:

- 03 - Dust emission (Offline version)
- 04 - SGP Soil Moisture (June 15-17, July 25-27 2006) (*May need to be split into two cases*)
- 07 - Hurricanes with aerosol contributions
- 14 - TexAQS2006

## Documentation

The NU-WRF Release 3 package contains documentation for the following:

- Accessing Source Code and Data
- Building the Software
- Running the Cases and Utilities

Note: More specific date targets will be established once the software requirements are approved.

## Milestones

1. **August 2011** - Development release with LVT, updated LIS config tool, fire emission preprocessor, GOCART2WRF enhancements
2. **September 2011 (\*)** - Beta release planned

(\*) Components not fully evaluated level of effort may change the scheduled milestone targets.